ROCKFISH ASSESSMENT STUDIES ON

HECETA BANK, OREGON, 1980-81

SUB-PROJECT
ANNUAL REPORT

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ABSTRACT

From January 1980 to January 1981 approximate monthly sampling of a unique rockfish (Scorpaenidae) fishing area on Heceta Bank, Oregon was undertaken using acoustic techniques and trawling aboard chartered commercial fishing vessels. Rankings of density of fish sign observed on acoustic transects were regressed against selected environmental variables. Acoustic abundance results showed no seasonal fluctuations nor were abundance ratings correlated to time of day. A significant correlation was obtained between rockfish abundance and feed abundance. Although regressions of acoustic estimates were significant each of the principal variables of weekly upwelling index, secchi depth, time of day, barometric pressure, feed abundance and tide fluctuations accounted for only a small part of the variance.

A relationship between trawl catch rate (lb/hr) and season or time of day was not observed. Catch rates were correlated with bottom temperature, maximum tide change and tide change during the tow. Quarterly biomass estimates calculated by the area-swept method varied as much as 20-fold.

We concluded that the method of ranking abundance based on acoustic signals was unsuccessful. More importantly we were unable to predict conditions during which canary rockfish (*Sebastes pinniger*) were available to trawlable areas.

INTRODUCTION

The need for an adequate data base to properly manage rockfish species (Scorpaenidae) of the Pacific coast has increased over the past decade. The enactment of the Magnuson Fishery Conservation and Management Act of 1976 and a continual increase in rockfish landings both have stimulated work on assessment of rockfish stocks (Gunderson and Lenarz, 1980). Two coastwide rockfish resource assessment surveys were completed by the National Marine Fisheries Service, in 1977 and 1980. Some results of these surveys were questioned, particularly by industry, as well as managers. In several instances survey results were inconsistent with fishery results which led managers to seek alternative stock assessment methods.

Unfortunately, reliable stock abundance estimates of most rockfish species found off the Pacific coast are difficult to obtain. Traditional survey methodology (area swept) works well for some other species such as flatfish but has not always resulted in accurate abundance estimates for rockfish species. Most survey methods to date have relied heavily on area-swept expansion of catch data made from sample trawls. However, variance of sample trawl data is usually high, due to the aggregating nature of most rockfish species.

Other rockfish behavior characteristics are also known to complicate assessment surveys. Many rockfish species spend much time aggregated over areas of untrawlable bottom (Boehlert 1980, Gunderson and Sample 1980). Seasonal as well as shorter term changes in distribution are not well understood. These changes in distribution may also bias rockfish abundance estimates since most surveys are completed during the summer months and actual fishing time may be weeks or months removed from the planning stage.

The Oregon Department of Fish and Wildlife initiated a study in 1980 to improve methodology for assessment of rockfish stocks. Two objectives were established. Our first objective was to determine if the electronic fish locating equipment on board well-equipped commercial fishing vessels could be used to produce accurate rockfish abundance estimates. Because acoustic instruments are becoming an increasingly important tool for biologists in estimating fish abundance in many fisheries throughout the world (Forbes and Nakken, 1972, Dark, et al, 1980) we wished to examine the possibility of obtaining abundance estimates of demersal rockfish species using electronic instruments as an alternative to estimates made by area-swept expansion of sample trawl catches. If successful, accuracy of rockfish abundance estimates might be improved. In recent years, many boats within the Oregon trawl fleet have acquired sophisticated echo-sounders, fish scopes, and sonar equipment to aid in fish detection. This equipment, combined with the commercial fishermen's knowledge of the fishing grounds and fishing gear, provided a unique tool for a study of rockfish assessment methodology.

Our second objective was to determine what factors affect rockfish availability and distribution within a survey area. By restricting our survey to one specific area and sampling throughout the year, we hoped to examine environmental factors affecting seasonal and short term changes in rockfish distribution and abundance. This type of work should provide insight into possible biases in data gathered during surveys conducted over short time periods. Results from a year-long sampling program might also provide information on the most appropriate time to schedule short intensive surveys.

METHODS

Study Area

The outer edge of Heceta Bank was chosen as the study area (Figure 1). The survey area was located approximately 20 miles (37 km) south of Newport, Oregon and 45 miles (83 km) offshore. The northern and southern boundaries were at 44°20' and 44°02' north latitude, respectively. The eastern and western boundaries of the study area were marked by the 70 and 130 fathom (128-238 m) contours.

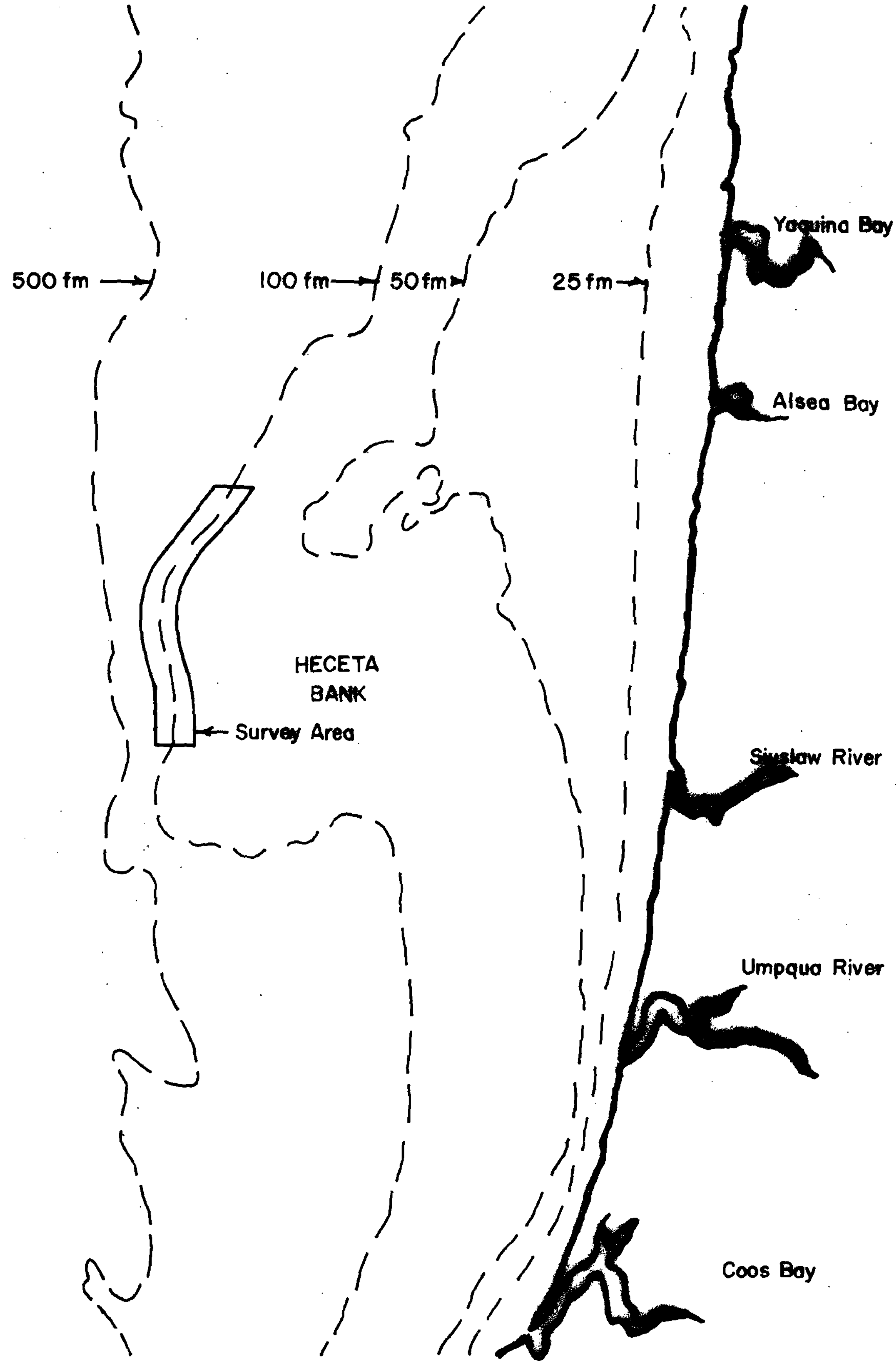

FIGURE I. Map of the Heceta Bank rockfish survey area.

This area was chosen as a study site for two reasons. Heceta Bank has become an important commercial fishing ground for canary rockfish, *Sebastes pinniger*, in recent years and canary rockfish was the dominant rockfish species in the survey area, accounting for over 90 percent of the species composition in many catches. Because of the time and funding available, we decided to concentrate our efforts on one species. Thus, Heceta Bank appeared to be an appropriate area to work. Secondly, the canary rockfish fishing ground at Heceta Bank were small enough to make adequate acoustic transect coverage feasible within the time alloted for each charter survey.

We completed nine chartered surveys between March 1980 and January 1981 for a total of 18 days at sea. An additional 13 days at sea were spent in a "ride-along" capacity on commercial vessels in the Heceta Bank area between January and December of 1980. These trips increased the data available on environmental parameters and catch rate needed to accomplish objective two.

Transects

Each chartered survey consisted of 15 transects ranging from 70 to 130 fathoms in depth. Each transect generally consisted of rough, untrawlable bottom terrain between 70 and 85-90 fathoms (155-165 m). Smoother bottom terrain and steeper slopes were characteristic of the deeper section of each transect. All transects were run during daylight hours as canary rockfish schools normally disperse at night.

Local commercial fishing vessels familiar with the Heceta Bank area were chartered for the surveys. Echo-sounder models used in the surveys included an Atlas Echograph (611), Japanese Radio Company's Zoom Echo-Sounder, Model NJA-310, and a Furuno Echo-Sounder, Model ES-5[1/]. The echo-sounder provided a permanent copy of depth, bottom terrain, and sign of fish and feed. All boats were also equipped with fish scopes for additional identification capability. While it does not provide a permanent copy of its transmissions, the fish scope provides better resolution between large rockfish species and feed sign than is obtained by use of the echo-sounder alone. In the context of this report, "feed sign" on the chart recordings were those markings that did not produce strong flashes on the fish scope and were not recognizable as other fish species by the skipper. Therefore, these markings may represent small fish species as well as squid or other invertebrates. A permanent record of each transect was kept from the echo-sounder, with all observed sign of fish and feed schools being noted. Distinction between fish and feed "sign" on the echo-sounder was differentiated with the use of the fish scope and the skipper's expertise. Whenever bottom terrain permitted, trawl hauls were made on observed schools to obtain species composition.

Environment Variables

Measurable environmental parameters were recorded on each transect and trawl haul. Other environmental measurements were later obtained from other

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[1/] Names of the manufacturers product does not constitute endorsement.

sources and also examined for correlations with fish and/or feed abundance (Table 1). The "upwelling index" variable used in this analysis was actually

Table 1. Variables Used in Analysis of Rockfish Abundance and Distribution of Heceta Bank Rockfish Survey.

Variable
Month
Time of day
Bottom temperature**
Surface temperature
Wind velocity
Wave height
Surface current velocity
Surface current direction
Cloud cover
Light intensity at surface
Secchi depth Upwelling index*
Barometric pressure on sampling day
Change in barometric pressure from previous day
Maximum tide change*
Tide change during sample*
Feed abundance, estimated from chart recorder
Feed abundance/upwelling index
Feed abundance/light intensity

* See text for explanation
** Trawl data only

a measurement of wind velocity and its northerly or southerly component, as measured by Oregon State University at the south jetty of Yaquina Bay. Cumulative averages from one to 14 days before the day of sampling were examined for best correlation with fish abundance ratings. The average of seven days before sampling produced the best correlation and was thus used in further multiple regression analyses with other environmental variables.

No measure of on-bottom current patterns or velocity was available. Stevenson (OSU doctorate thesis, 1966) and Collins (OSU doctorate thesis, 1967) both indicated tidal changes could significantly affect current patterns offshore, although timing and magnitude are not yet well defined. Commercial fishermen sometimes assert that tidal fluctuations seem to affect catch rates. We therefore included two measures of tidal movement in the analysis. The variable "maximum daily tide change" was a measure of the maximum tide change for the day of sampling, regardless of whether the tide was incoming or outgoing. The variable "tide change during sample" represented the tide change that occurred at the actual time of the transect. This value was given a negative sign if the tide was outgoing and a positive sign if the tide was incoming.

Bottom temperature was obtained from a modified mechanical bathythermograph attached to the headrope of the trawl.

A qualitative relative abundance rank of 1-4 was established for fish and feed sign from the echo-sounder recordings. Rank 1 represented no sign observed; rank 2 represented a few scattered individuals or small schools; rank 3 represented moderate abundance; and rank 4 represented large abundance. Criteria for each rank were based on the bottom expansion scale of the echo-sounder, and notes taken on the response of the fish scope to each sighting. The relative abundance rank was applied to rough bottom and smooth bottom terrain for each echo transect.

A relative abundance rank was also established for each trawl haul taken during the survey and ride-along trips using the same criteria as those established for the transects.

The catch rate of all tows was calculated as pounds per hour towed. Catch rates were established for canary rockfish and for all rockfish combined. These two catch rates were similar because most catches consisted of greater than 90 percent canary rockfish. Some tows were stopped prematurely because of the trawl hanging up on the bottom; therefore, only tows lasting over 10 minutes were used for this analysis. Tows from chartered trips and ride-along trips were combined, giving a total of 62 tows with usable catch rates.

We used multiple regression analysis to help analyze factors affecting fish abundance seen on the transects. Multiple regression analysis was again used to examine environmental parameters and standardized trawl catch data during the charter and ride-along trips. Regressions were calculated for all transects combined (1-15) and for only transects 1-9 because transects 10-15 showed low abundance throughout the entire survey.

Precision of CPUE as an Index of Abundance

Since a large number of tows were completed within a small geographic area, the survey provided an opportunity to examine the precision of CPUE estimates obtained by trawling. Once the variability in catch rate was known we calculated the number of tows needed to reach a given level of precision.

To examine this problem we calculated power curves for the 80% confidence interval of mean catch/hour of trawl caught canary rockfish. Separate curves were generated for tows made as part of our rockfish survey and for those tows made during ride-along commercial trips. This was done because some survey tows were conducted in areas where the electronic equipment indicated few rockfish were available in order to obtain samples throughout the survey area. Trawling done on commercial trips was usually restricted to those occasions where electronic equipment indicated rockfish were present in sufficient quantity to make trawling economically worthwhile. The power curves were generated using the formula:

$$80\%\ \mathrm{C.I.} = \frac{t_{20}\ \mathrm{CV}}{N} \quad \text{where:}$$

CV = coefficient of variation $\left(\frac{\text{standard deviation}}{\text{sample mean}}\right)$

N = number of survey units

t_{20}: students t value associated with N-1 d.f.

RESULTS

Factors Affecting Acoustic Abundance Estimates

No seasonal fluctuation in canary rockfish abundance was evident over either rough or smooth terrain using acoustic estimates of abundance. Greater abundance was observed over rough terrain than over smooth terrain (Figure 2). The abundance rankings were also not correlated to time of day (Figure 3).

There was a significant positive correlation between rockfish abundance and feed abundance over both rough and smooth ground (Tables 2 and 3). The variable of feed abundance/upwelling index was also positively correlated with rockfish abundance over smooth terrain when all transects were combined in the analysis. However, in no case was more than 20% of the variability in fish abundance explained.

When feed abundance variables were removed from the analysis, no combination of environmental parameters could explain more than 12% of the variation in rockfish abundance. When all transects were combined, rockfish abundance over rough terrain was positively and significantly correlated to the weekly upwelling index, secchi depth, and time of day, and was negatively and significantly correlated with barometric pressure (Table 2). Surface light intensity was the only variable significantly correlated with rockfish abundance over smooth terrain when all transects were included in the analysis, but this regression explained only 10% of the variability in fish abundance (Table 3). Omitting transects 10-15 caused surface temperature to be significantly correlated with fish abundance, but the coefficient of determination dropped to 0.066 (Table 3).

Factors Affecting Trawl Catch Rate

No relationship was evident between catch rates of rockfish and month or time of day (Figures 4 and 5). The time of day measurements again only represent

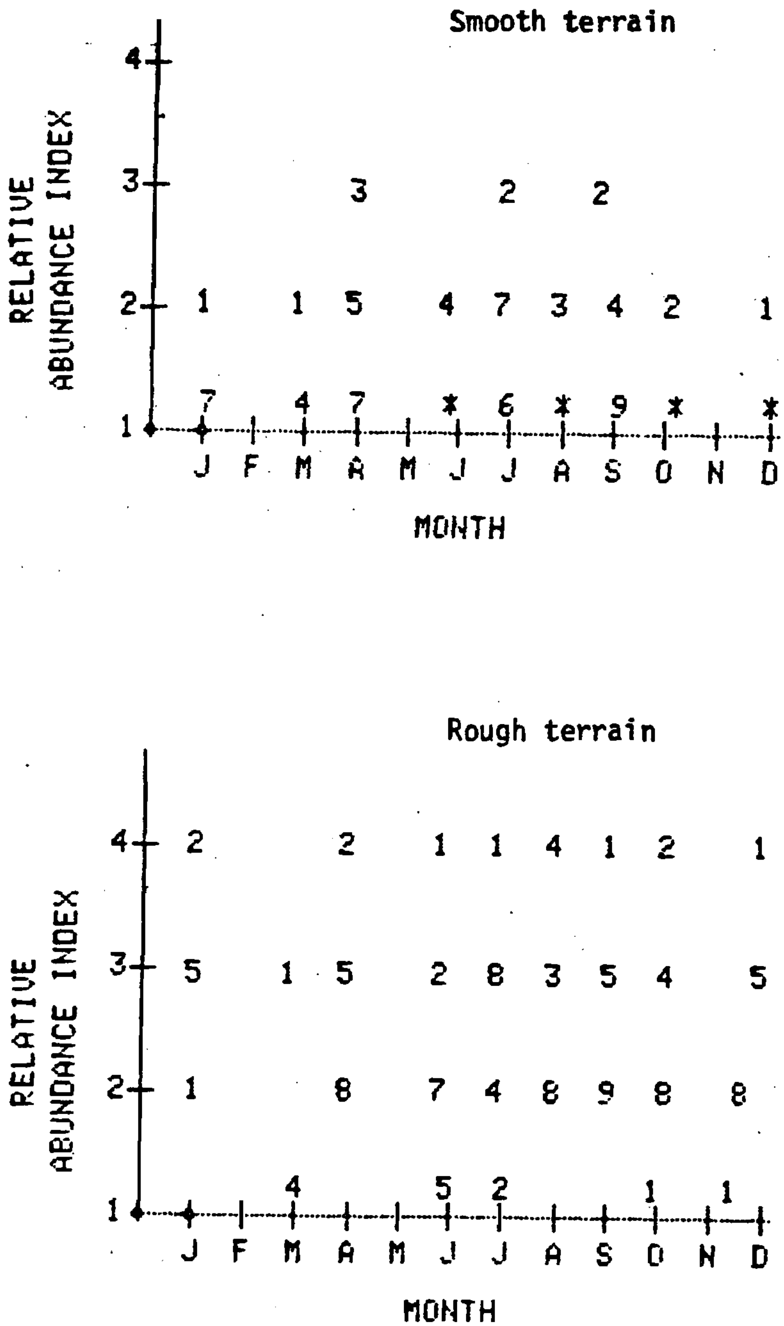
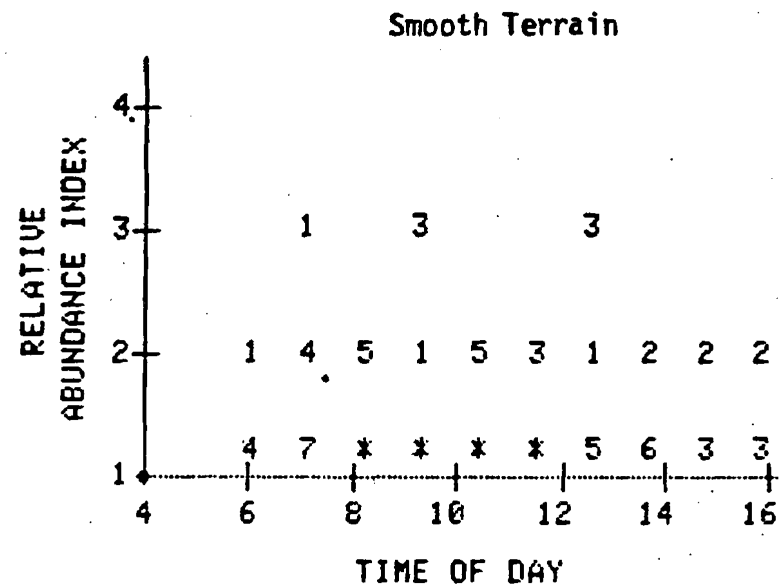


Figure 2. Relative abundance of rockfish observed by month on the acoustic transects. Numbers indicate frequency of abundance rankings. Asterisks indicate more than nine data points.



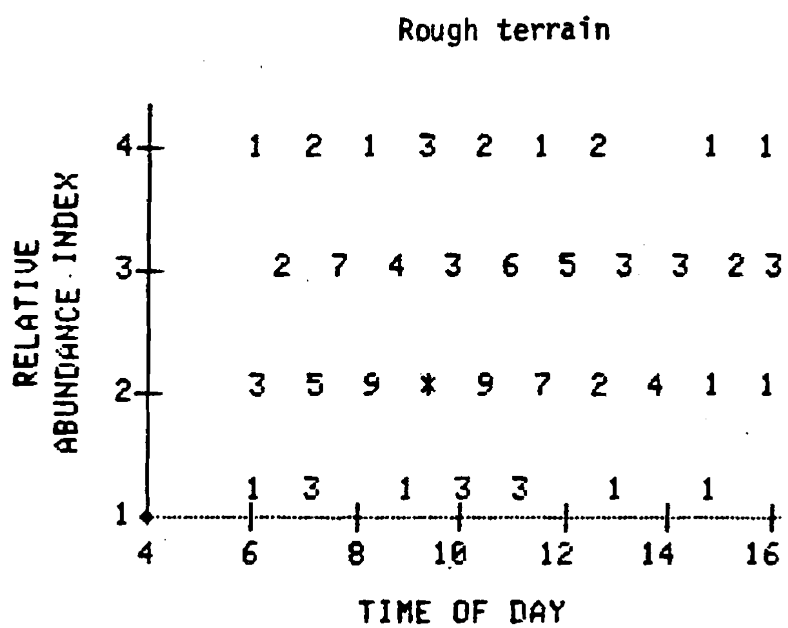


Figure 3. Relative abundance of rockfish observed by time of day on acoustic transects. Numbers indicate frequency of abundance rankings. Asterisks indicate more than nine data points.

Table 2. Multiple Regression of Factors Affecting Rockfish Abundance in the Rough Terrain Portion of the Heceta Bank Survey Area in 1980-81. Abundance Estimates Obtained from Electronic Fish Locating Equipment.

Dependent variable	Comments	N	R^2	Independent variable	Regression coefficient	Partial t
Rockfish abundance over rough terrain	Transects 1-15 All variables	112	0.152	Constant	1.217	4.25 **
				Feed abundance[a]	0.467	4.46 **
Rockfish abundance over rough terrain	Transects 1-15 Envir. variables[b]	112	0.120	Constant	57.400	2.02 *
				Weekly upwelling index[c]	0.079	3.68 **
				Secchi depth	0.034	2.96 **
				Time of day	0.065	2.05 *
				Barometric pressure	-0.056	-1.99 *
Rockfish abundance over rough terrain	Transects 1-9 All variables	70	.209	Constant	1.078	2.79 **
				Feed abundance	0.5910	4.27 **
Rockfish abundance over rough terrain	Transects 1-9 Envir. variables[b]	70	.053	Constant	2.686	26.88 **
				Tide fluctuation[c]	0.026	1.97 *

a Feed abundance over rough bottom. Abundance estimated from electronic equipment
b Feed abundance variables removed from model
c See text for explanation

* Indicates significance at the 95% level
** Indicates significance at the 99% level

Table 3. Multiple Regression of Factors Affecting Rockfish Abundance in the Smooth Terrain Portion of the Heceta Bank Survey Area in 1980-81. Abundance Estimates Obtained from Electronic Fish Locating Equipment.

Dependent variable	Comments	N	R^2	Independent variable	Regression coefficient	Partial t
Rockfish abundance over smooth terrain	Transects 1-15	112	0.151	Constant	1.154	16.80 **
	All variables			(feed abund) (weekly upwelling index)	0.0001	4.43 **
Rockfish abundance over smooth terrain	Transects 1-15	112	0.100	Constant	1.167	15.47 **
	Envir. variables			Surface light intensity	0.0002	3.51 **
Rockfish abundance over smooth terrain	Transects 1-9	70	0.108	Constant	0.840	4.02 **
	All variables			Feed abundance	0.304	2.89 **
Rockfish abundance over smooth terrain	Transects 1-9	70	0.066	Constant	0.467	1.08
	Envir. variables			Surface temp.	0.071	2.20 *

* Indicates significance at 95% level
** Indicates significance at 99% level

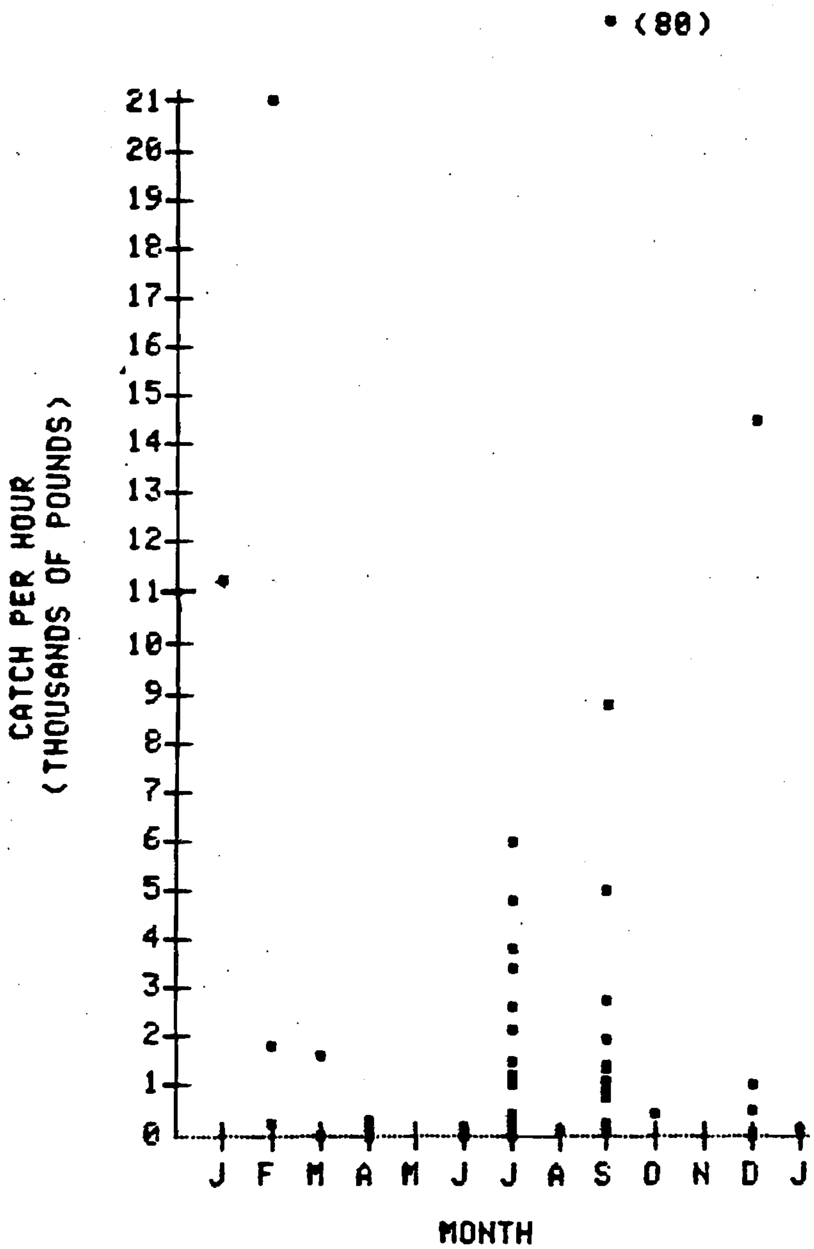


Figure 4. Catch per hour of canary rockfish by month on Heceta Bank.

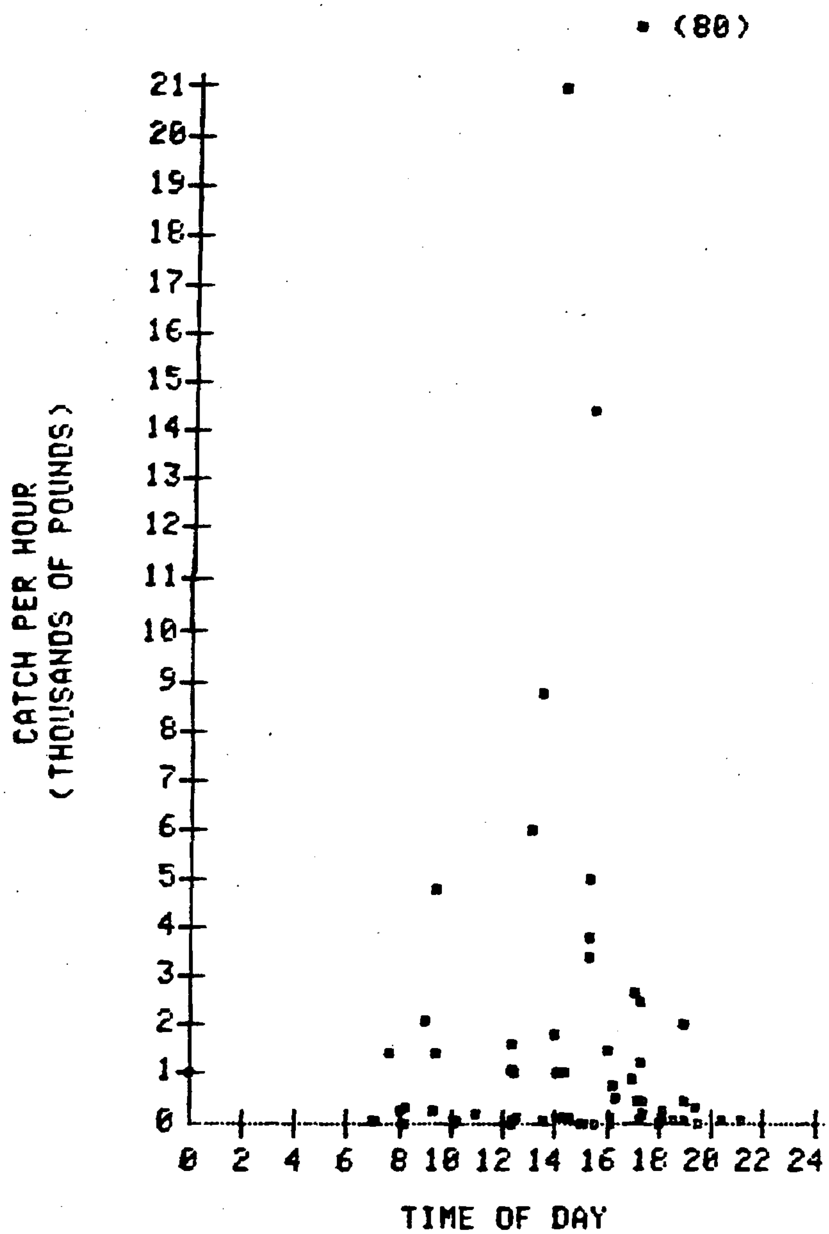


Figure 5. Catch per hour of canary rockfish by time of day on Heceta Bank.

daylight hours, since canary rockfish schools generally disperse at night and no commercial fishing is normally done.

Multiple regression analysis showed that catch rate of canary rockfish was significantly and negatively correlated with bottom temperature and was significantly and positively correlated with maximum tide change and tide change during the tow (Table 4). However, only a small amount of the variability in catch rate was accounted for. Correlation coefficients were 0.27 for canary rockfish and 0.26 for total rockfish.

Comparison of Trawl CPUE with Electronic Abundance Estimates

Acoustic abundance estimates were also made on echo-sounder chart recordings of each tow. Regression analysis of catch rate of canary rockfish and total rockfish on the acoustic abundance estimates were significant but explained only 25 and 28 percent of the variability in catch rate.

Fish Schooling Behavior

Observations of school height and distance off the bottom were made for both rockfish schools and feed schools on all transects. No significant correlations could be found between these measurements and the environmental parameters in Table 1.

Precision of CPUE as an Index of Abundance

Power curves for either survey or commercial tows showed that even with large numbers of tows (>75), the greatest precision that could be obtained was to estimate the mean catch/hour of canary rockfish with ±50% about 80% of the time. If the number of tows in the area was less than 25, the ability to detect a change in the mean catch rate diminished rapidly (Figure 6).

Although no seasonal change in CPUE was observed during the survey, power curves were also constructed for two short time intervals to reduce the possibility of CPUE variability being attributed to seasonal changes in abundance. Adequate tows were made between July 8-10 and again between September 26-28 (14 and 13 tows, respectively) to allow such an estimate of variance to be calculated. The power curves generated from each of the time periods showed that a large number of samples (>50 tows) would be needed to estimate the mean CPUE within ±50% about 80% of the time (Figure 7). The catch rate of tows made in July was less variable than those made in September, and therefore showed a higher degree of precision for a given sample size (Figure 4). This difference was caused primarily by one extremely large catch from the September series of tows.

DISCUSSION

The rockfish survey at Heceta Bank fell short of outlining an acceptable methodology for stock assessment surveys of rockfish species. However, by examining one fishery ground over an entire year, we hope some insight has

Table 4. Multiple Regression of Factors Affecting Canary Rockfish and Total Rockfish Abundance in Trawl Catches During the Heceta Bank Survey. Trawl Catches Calculated in Pounds/Hr.

Dependent variable	Comments	N	R^2	Independent variable	Regression coefficient	Partial t
S. pinniger	All tows	53	0.268	Constant	21914.4	1.37
Catch/hr	Envir. variables			Bottom temperature	-7764.6	-2.94 **
				Maximum tide change	2832.8	2.89 **
				Tide change during tow	471.1	2.28 *
Total rockfish	All tows	53	0.262	Constant	21830.7	1.35
Catch/hr	Envir. variables			Bottom temperature	-7746.3	-2.88 **
				Maximum tide change	2865.0	2.88 **
				Tide change during tow	467.3	2.23 *

* Indicates significance at 95% level
** Indicates significance at 99% level

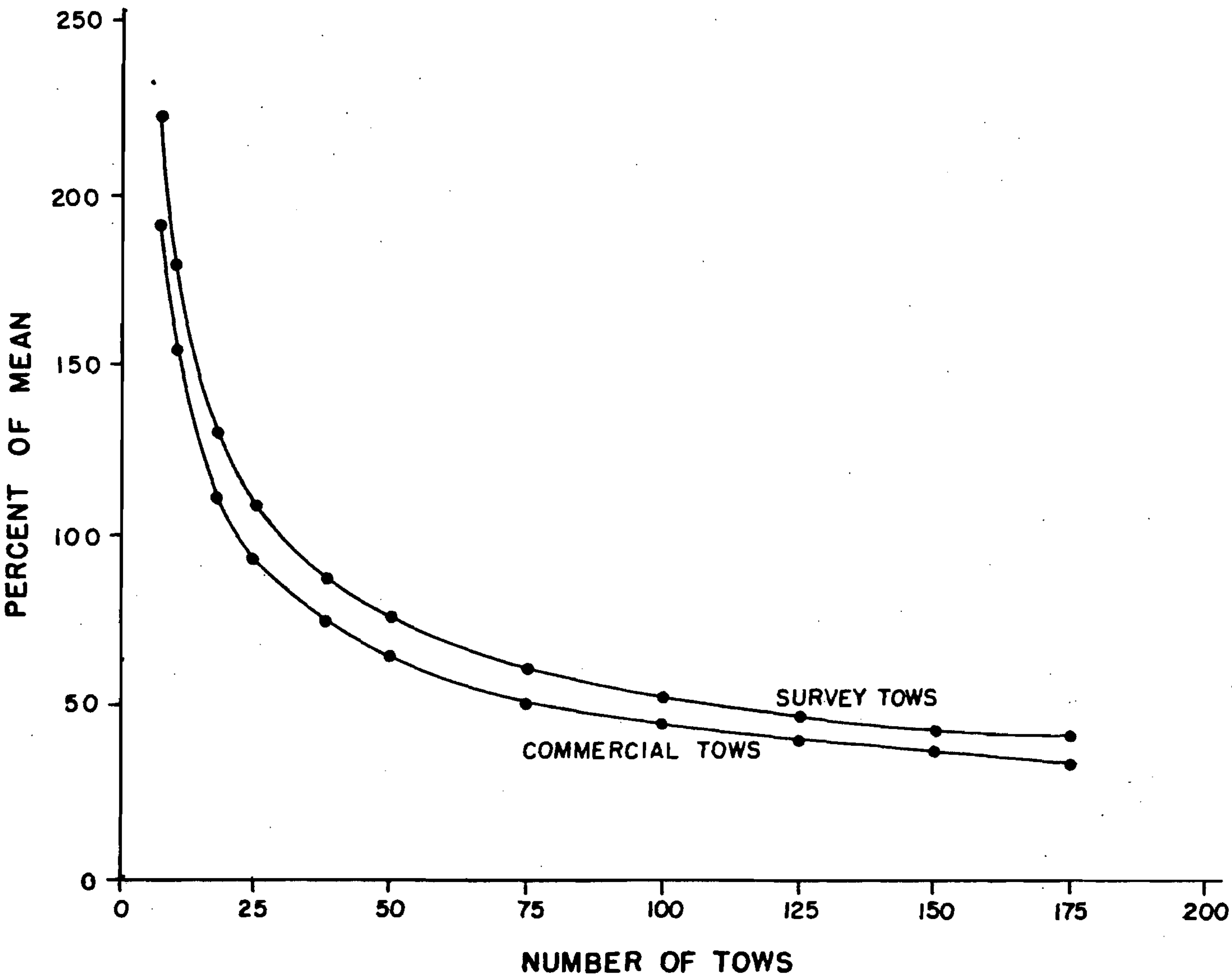


Figure 6. The relationship between the 80% confidence interval expressed as a percent of the mean catch/hr of canary rockfish and the number of tows made during the Heceta Bank Rockfish Survey and during commercial fishing trips.

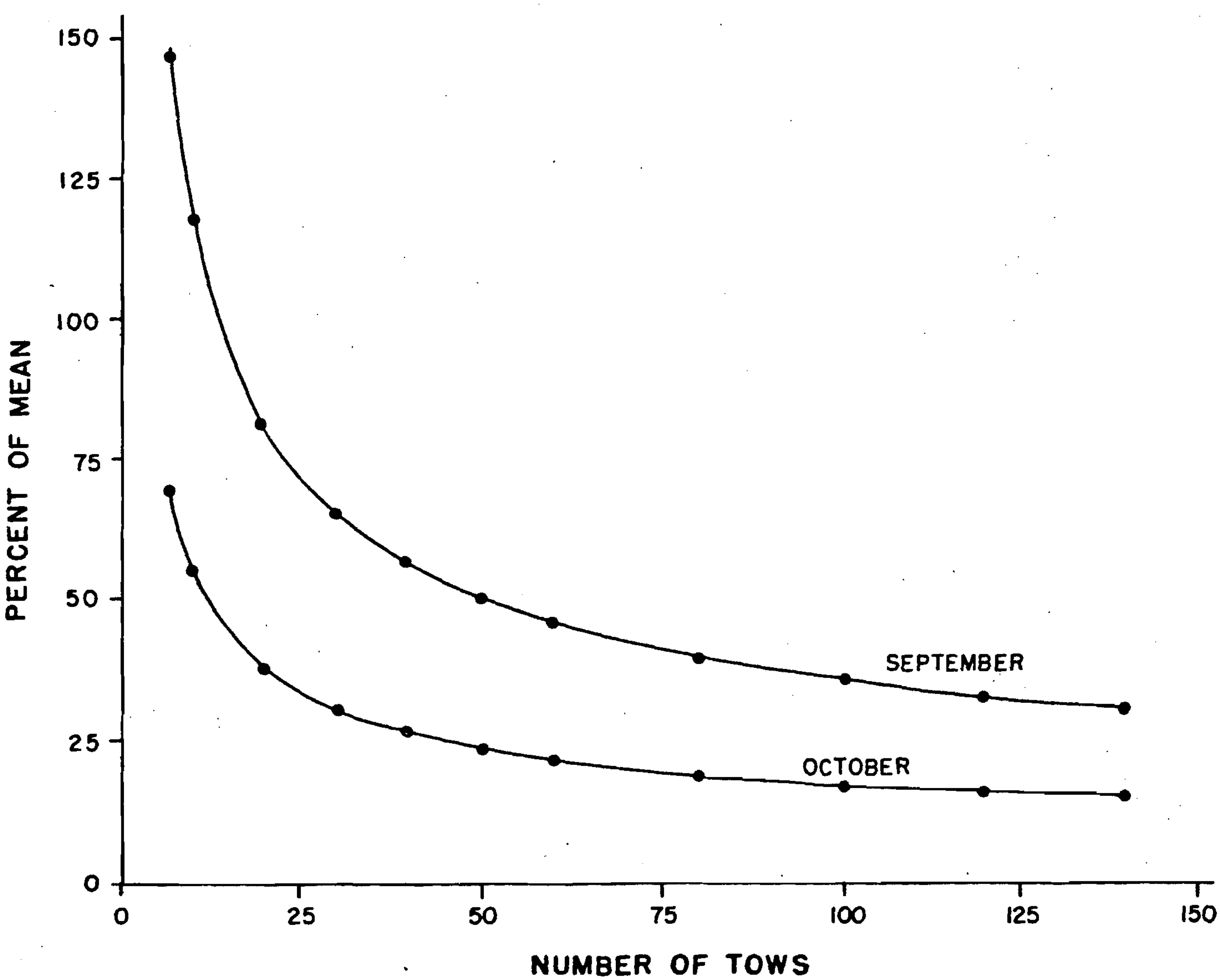


Figure 7. The relationship between the 80% confidence interval expressed as a percent of the mean catch/hr of canary rockfish and the number of tows made during two different time periods in 1980.

been given to the problems associated with present surveys. Conclusions given in this section apply specifically to our present survey on Heceta Bank, but some may be applicable to other rockfish species along the Pacific coast.

We found it impossible to obtain reliable quantitative estimates of abundance of rockfish with the electronic equipment available on the surveys. The principal problem was the inability to accurately count individual rockfish schools and determine the school size. Although canary rockfish sometimes produced dense, easily recognizable schools on the echo-sounder, they were often scattered on or near the bottom with large amounts of feed. In this case, "fish sign" was often impossible to differentiate from "feed sign" without reference to the fish scope. Even with this instrument, it was impossible to assign a percentage of fish to feed, or estimate the total area of the school scattered across the bottom. Therefore, a qualitative index of abundance was the only estimate of abundance made for the transects.

Although the acoustic abundance estimates made during trawls were significantly correlated to the actual catch rate for the same tow, they explained only 25 to 28 percent of the variability in canary rockfish and total rockfish catch rates. Several explanations are possible. First, even the qualitative estimates of relative abundance assigned to the rockfish "sign" on the chart recordings may be inaccurate. Secondly, trawl catches may not always take a representative sample of what is seen on the chart recorder. This may result from gear malfunction or rapid dispersal of fish. Currents may also push the trawl to the side of the fishing vessel, so the trawl is no longer fishing directly in the path of the echo-sounder. More sophisticated electronic gear may provide better resolution, although accurate abundance estimates using electronic equipment may remain elusive for demersal species such as canary rockfish.

The environmental parameters measured could explain only a small portion of variability in canary rockfish abundance and distribution in the survey area. This study was limited to several days at sea each month and had limited equipment to measure environmental parameters. Ideally, measurements of light intensity, temperature, current direction and current velocity should have been taken in the water column where the fish were located. Future studies to correlate rockfish distribution patterns to environmental parameters should use equipment that will provide these measurements.

Accurate survey methodology for canary rockfish cannot rely solely upon expansion of trawl catches. Catches of canary rockfish were often low during our surveys, not because fish were not present in the survey area, but because they remained over untrawlable bottom terrain. Catch rates were seen to change dramatically as schools of fish occasionally moved to trawable areas. The fishing expertise of the skipper and familiarity with the grounds were also extremely important in determining catch. These short-term changes in availability of canary rockfish appeared to be more prevalent than long term seasonal fluctuations in availability.

Because of the high variability in catch rate of canary rockfish, over 75 tows would be needed to obtain an estimate within 50% of the true mean 80%

of the time. If catch rate of other demersal rockfish are as variable as they were for canary rockfish on Heceta Bank, there are serious implications for other rockfish surveys that rely on expansion of catch rate to estimate biomass. To illustrate this point we calculated biomass by the area-swept method,

$$B = \frac{(A)}{(a)} \times \overline{CPUE} \quad \text{where:}$$

A = total trawlable area

a = area swept/nautical mile

$\overline{CPUE}$ = mean catch rate/nautical mile

Biomass was estimated for four seasonal periods selected to correspond to important phases in the life history of canary rockfish. The November-January period represents the spawning period.

Mean catch/nautical mile (lbs/nm) and corresponding biomass estimates varied greatly for each time period. However, the larger estimates for the November-January period and the August-October period were the results of one large catch in each of these time periods. When these two tows were removed from the data, the mean catch/nm for the November-January period dropped from 9,810 lbs/nm to 1,165 lbs/nm, and the August-October estimate dropped from 3,038 lbs/nm to 719 lbs/nm. Large catches of canary rockfish were occasionally made by the commercial fleet between February and July, so apparent seasonal differences were probably caused by insufficient sampling rather than seasonal changes in distribution.

The estimates of biomass should not be used in a quantitative sense since a basic assumption of the area-swept method was violated. The tows were not randomly selected. Most tows were target tows on fish previously located with acoustical equipment. This would probably over-estimate biomass. Non-randomness may not be a major problem though, because most tows occurred on the only trawlable bottom within the study area.

The purpose of calculating biomass was not to provide definitive measures of abundance but rather to show the effects of availability. Estimates ranged from 692,000 lbs in early summer to 13,945,000 lbs (+1,915%) in early winter, nearly a 20-fold increase (Table 5). This degree of difference seriously strains the credibility of the area-swept method with respect to canary rockfish and perhaps other highly aggregated species as well. If availability cannot be predicted, which we could not, or if availability is not understood then results from area-swept methodology must be questioned. The cost and time needed for adequate sampling on a coastwide survey may be too large to obtain a level of precision sufficient to calculate meaningful biomass estimates.

Table 5. Estimates of Biomass Determined by the Area Swept Method for Canary Rockfish on Trawlable Area of Heceta Bank in 1980.

Time period	Average catch, lbs/nm	n	Estimates, in pounds Biomass	±95% CL
Nov-Jan	9,810	7	13,945,000	23,055,000
Feb-Apr	928	12	1,319,000	2,390,000
May-Jul	487	25	692,000	434,000
Aug-Oct	3,038	15	4,319,000	6,960,000
All periods combined	2,088	59	2,968,000	2,828,000

SUMMARY

1. The purpose of the study was to improve upon methodology used in previous surveys to estimate abundance of rockfish with particular emphasis on canary rockfish.

2. The study was conducted on the outer edge of Heceta Bank using chartered commercial fishing vessels. Chartered trips were conducted monthly in most cases over a one year period. Sea time was extended by observing on routine commercial fishing trips to the same area.

3. Acoustic track lines were run on each chartered cruise that ranged from 70-150 fms over both smooth and rough terrain. Acoustic sign of fish was ranked on a relative scale of 1-4.

4. Results from acoustic data did not show seasonal or daily changes in abundance rankings, i.e., high or low abundance was without trend.

5. Significant correlations were obtained with the variables of weekly upwelling index, secchi depth, time of day, barometric pressure, feed abundance and tidal fluctuations but each variable accounted for only a small part of the variance.

6. Regressions of trawl catch rate against season or time of day were not significant but catch rates were correlated with bottom temperature and tidal change.

7. Biomass estimates determined by the area swept method varied by a factor of nearly 20.

8. The study was not successful in developing an alternative methodology to assess rockfish abundance. Availability of rock on trawlable bottom was not predictable.

ACKNOWLEDGMENTS

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